IN THE SPECIFICATION:

Please replace the second full paragraph on page 2 with the following:

Semiconductor devices of a leads over chip (LOC) configuration, as well as flip-chip type or configuration, including chip scale packages (CSPs), are widely used in the electronics industry. The electrical characteristics of semiconductor devices are typically tested by placing a semiconductor device facedown on a test substrate to establish an electrical connection between contact pads on a surface of the semiconductor device and corresponding test pads of the test substrate. The test pads of the test substrate are arranged in a mirror image to the corresponding contact pads on the semiconductor device. Conductive structures, typically solder bumps, conductive pillars, conductor-filled epoxy, or z-axis conductive elastomer, are sometimes applied to and protrude from the contact pads of the tested semiconductor device prior to testing of the semiconductor device. Conductive structures facilitate desired communication between the contact pads of the semiconductor device and the corresponding test pads of the test substrate and may also be employed later to effect a permanent connection to a carrier substrate.

Please replace the paragraph bridging pages 2 and 3 with the following:

When the contact pads are concentrated over a small area of the semiconductor device, such as in one or more centrally located rows (e.g., LOC-type dice) or adjacent a single edge of the semiconductor device, or are not positioned over a large enough area of the semiconductor device that conductive structures secured thereto will support the semiconductor device in facedown orientation on a test substrate, conductive structures that protrude from the contact pads may lend to instability as the semiconductor device is disposed on a test substrate. Consequently, a semiconductor device with contact pads concentrated over a relatively small area thereof is prone to being tipped or tilted from a plane that is substantially parallel to the plane of the test substrate.

Please replace the first full paragraph on 5 with the following:

The mathematical simulation or model is then employed to generate an actual object by building the object, layer by superimposed layer. A wide variety of approaches to stereolithography by different companies has resulted in techniques for fabrication of objects from both metallic and nonmetallic materials. Regardless of the material employed to fabricate an object, stereolithographic techniques usually involve disposition of a layer of unconsolidated or unfixed material corresponding to each layer within the object boundaries, followed by selective consolidation or fixation of the material to at least a partially consolidated, or semisolid, state in those areas of a given layer corresponding to portions of the object, the consolidated or fixed material also at that time being substantially concurrently bonded to a lower layer of the object to be fabricated. The unconsolidated material employed to build an object may be supplied in particulate or liquid form, and the material itself may be consolidated or fixed or a separate binder material may be employed to bond material particles to one another and to those of a previously formed layer. In some instances, thin sheets of material may be superimposed to build an object, each sheet being fixed to a next lower sheet and unwanted portions of each sheet removed, a stack of such sheets defining the completed object. When particulate materials are employed, resolution of object surfaces is highly dependent upon particle size, whereas when a liquid is employed, surface resolution is highly dependent upon the minimum surface area of the liquid which can be fixed and the minimum thickness of a layer that can be generated. Of course, in either case, resolution and accuracy of object reproduction from the CAD file is also dependent upon the ability of the apparatus used to fix the material to precisely track the mathematical instructions indicating solid areas and boundaries for each layer of material. Toward that end, and depending upon the layer being fixed, various fixation approaches have been employed, including particle bombardment (electron beams), disposing a binder or other fixative (such as by ink-jet printing techniques), or irradiation using heat or specific wavelength ranges.

Please replace the first full paragraph on page 6 with the following:

In more recent years, stereolithography has been employed to develop and refine object designs in relatively inexpensive materials and has also been used to fabricate small quantities of objects where the cost of conventional fabrication techniques is prohibitive for same, such as in the case of plastic objects conventionally formed by injection molding. It is also known to employ stereolithography in the custom fabrication of products generally built in small quantities or where a product design is rendered only once. Finally, it has been appreciated in some industries that stereolithography provides a capability to fabricate products, such as those including closed interior chambers or convoluted passageways, which cannot be fabricated satisfactorily using conventional manufacturing techniques. It has also been recognized in some industries that a stereolithographic object or component may be formed or built around another, pre-existing object or component to create a larger product.

A4

Please replace the first full paragraph on page 7 with the following:

The present invention includes stabilizers, which are also referred to herein as support structures or as outriggers, that stabilize a semiconductor device when the semiconductor device is temporarily disposed upon a test substrate. Stabilizers incorporating teachings of the present invention are particularly useful for testing semiconductor devices having contact pads that are arranged in a manner that, when conductive structures are secured to the contact pads, the conductive structures will not prevent the semiconductor device from tilting or tipping. Such tilting or tipping can occur, for example, when the contact pads of the semiconductor devices and, thus, the conductive structures protruding therefrom, are concentrated in a small area (e.g., less than half) of the semiconductor device active surface, or are otherwise located in a pattern susceptible to tilting. Examples of semiconductor devices having concentrated contact pads include, without limitation, LOC-type semiconductor dice, the contact pads or bond pads of which are positioned in one or more centrally located rows, and semiconductor devices having contact pads disposed adjacent only a single edge thereof.

A5

Please replace the second full paragraph on page 7 with the following:

A6

Stabilizers incorporating teachings of the present invention are preferably configured to, along with the conductive structures protruding from a semiconductor device, stabilize a semiconductor device as it is disposed facedown upon a test substrate. In addition, the stabilizers of the present invention preferably maintain a substantially parallel relation between a test substrate and a semiconductor device to be disposed thereon. Moreover, the stabilizers may serve to limit stress on the semiconductor device during testing by "bottoming out" the semiconductor device as a compressive force is applied thereto. The stabilizers of the present invention may be configured as linear structures of substantially uniform height or as columns, bumps, or structures of other shapes that have substantially uniform heights.

Please replace the first full paragraph on page 8 with the following:

A7

The stabilizers are preferably positioned on the semiconductor device or the test substrate so as to, in combination with any conductive structures protruding from the semiconductor device, stabilize the semiconductor device upon the test substrate without interfering with electrical connections between the semiconductor device and the test substrate. For example, the stabilizers can be positioned at or near the corners of the surface of the semiconductor device, at or near the edges of the semieonductor device, or in an array over the surface of the semiconductor device. The stabilizers can also be positioned on the test substrate at locations thereof that correspond to the corners or opposing edges of a semiconductor device to be disposed thereon.

Please replace the second full paragraph on page 9 with the following:

A8

The stereolithographic method of fabricating the stabilizers of the present invention preferably includes the use of a machine vision system to locate the semiconductor devices or test substrates on which the stabilizers are to be fabricated, as well as the features or other components on or associated with the semiconductor devices or test substrates (e.g., solder bumps, contact pads, conductor traces, etc.). A machine vision system is preferably used to direct the alignment of a stereolithography system with each semiconductor device or test

A8 cont'd

substrate for material disposition purposes. Accordingly, the semiconductor devices or test substrates need not be precisely, mechanically aligned with respect to any component of the stereolithography system to practice the stereolithographic embodiment of the method of the present invention.

Please replace the second full paragraph on page 10 with the following:

A9

FIG. 1 is an enlarged perspective partial view of a semiconductor device positioned above a test substrate upon which the semiconductor device is to be disposed in a facedown orientation;

[Please replace the third full paragraph on page 10 with the following:]

FIG. 2 is a cross-sectional view of an assembly including a semiconductor device disposed on a test substrate in a facedown orientation;

Please replace the fifth full paragraph on page 10 with the following:

A10

FIG. 4 is a cross-sectional view of an assembly including another semiconductor device disposed on a test substrate in a facedown orientation, with the semiconductor device being tipped or tilted relative to the test substrate;

[Please replace the sixth full paragraph on page 10 with the following:]

FIG. 5 is an enlarged partial perspective assembly view of a semiconductor device having stabilizers on a surface thereof, the semiconductor device being disposed on a test substrate in a facedown orientation;

[Please replace the seventh full paragraph on page 10 with the following:]

FIG. 6 is a cross-sectional view of an assembly with a semiconductor device disposed on a test substrate in a facedown orientation, the semiconductor device including stabilizers to support the semiconductor device on the test substrate;

[Please replace the eighth full paragraph on page 10 with the following:]

A10 cont'd

FIG. 6A is a cross-sectional view of an assembly with a semiconductor device disposed on a test substrate in a facedown orientation, the test substrate including stabilizers to support the semiconductor device thereon;

[Please replace the ninth full paragraph on page 10 with the following:]

FIG. 6B is a cross-sectional view of an assembly with a semiconductor device disposed on a test substrate in a facedown orientation, the test substrate and semiconductor device each including stabilizers to support the semiconductor device on the test substrate;

Please replace the paragraph bridging pages 11 and 12 with the following:

A11

FIGs. 5 and 6 also illustrate semiconductor device 10 as having conductive structures, or conductors, protruding from contact pads 12, such as the bond pads of a semiconductor die, exposed at surface 14 thereof. The conductive structures are shown as solder bumps 30 and 30B secured to contact pads 12. Alternatively, the conductive structures may be any known type of conductive structure, suitably configured as balls, bumps, or pillars. The conductive structures can be formed from any type of conductive material or combination of materials known to be useful as a conductive structure of a semiconductor device, including, without limitation, solders, other metals, metal alloys, conductor filled epoxies, conductive epoxies, and z-axis conductive elastomers. Alternatively, semiconductor device 10 can have bare contact pads 12 that do not have conductive structures, such as solder bumps 30, protruding therefrom.

Please replace the second full paragraph on page 12 with the following:

A12

With continued reference to FIG. 6, stabilizers 50 that protrude too great a distance 54B from active surface 14 of semiconductor device 10 could prevent shorter conductive structures, such as solder bump 30B, from establishing a reliable electrical connection between a contact pad 12 of semiconductor device 10 and the corresponding test pad 40 of test substrate 20. Thus, stabilizers 50 preferably each extend between the planes of the surfaces 14 and 24 of semiconductor device 10 and test substrate 20 a distance 54 that is less than or equal to the

a12 cont'd

distance 28 that the planes or surfaces 14 and 24 are spaced apart when conductive structures, such as solder bumps 30, connect contact pads 12 to test pads 40. Accordingly, stabilizers 50 will not prevent the shortest conductive structure, such as solder bump 30B, from connecting a contact pad 12 and a test pad 40 upon assembly of semiconductor device 10 with test substrate 20.

Please replace the first full paragraph on page 14 with the following:

A13

By way of example, and not to limit the scope of the present invention, FIGs. 8-15 illustrate various exemplary arrangements, or footprints, of stabilizers 50 (in phantom) relative to a semiconductor device 10. FIGs. 8-15 thus illustrate exemplary locations at which stabilizers 50 may be positioned upon surface 14 of semiconductor device 10 or where stabilizers 50 located on a test substrate will be located relative surface 14 of semiconductor device 10 upon assembly of semiconductor device 10 with test substrate 20. Thus, in the ensuing description of FIGs. 8-15, stabilizers 50 are discussed in terms of the position in which they will be located upon disposal of semiconductor device 10 facedown on test substrate 20.

Please replace the third full paragraph on page 15 with the following:

A14

Several different processes can be used to fabricate stabilizers 50 in accordance with teachings of the present invention. As an example, stabilizers 50 can be preformed from plastic, epoxy or other resins by known processes, such as by molding or micromachining processes. These stabilizers 50 are then secured to surface 14 of semiconductor device 10 or to surface 24 of test substrate 20 by known processes, such as by the use of an adhesive.

Please replace the paragraph bridging pages 15 and 16 with the following:

A15

As another example, stabilizers 50 can be fabricated on surface 14, 24 of semiconductor device 10 or test substrate 20, respectively, by applying a layer of insulative material onto surface 14, 24 (e.g., by known deposition processes such as chemical vapor deposition ("CVD") or spin-on-glass ("SOG") processes) followed by removing unwanted portions of the layer (e.g., by use of photomask and etch processes).

Please replace the third full paragraph on page 17 with the following:

Apparatus 80 also includes a reservoir 84 (which may comprise a removable reservoir interchangeable with others containing different materials) of liquid material 86 to be employed in fabricating the intended object. In the currently preferred embodiment, the liquid is a photo-curable polymer, or "photopolymer", that cures in response to light in the UV wavelength range. The surface level 88 of material 86 is automatically maintained at an extremely precise, constant magnitude by devices known in the art responsive to output of sensors within apparatus 80 and preferably under control of computer 82. A support platform or elevator 90, precisely vertically movable in fine, repeatable increments responsive to control of computer 82, is located for movement downward into and upward out of material 86 in reservoir 84.

A16

Please replace the second full paragraph on page 18 with the following:

Apparatus 80 has a UV wavelength range laser plus associated optics and galvanometers (collectively identified as laser 92) for controlling the scan of laser beam 96 in the X-Y plane across platform 90 and has associated therewith mirror 94 to reflect beam 96 downwardly as beam 98 toward surface 100 of platform 90. Beam 98 is traversed in a selected pattern in the X-Y plane, that is to say in a plane parallel to surface 100, by initiation of the galvanometers under control of computer 82 to at least partially cure, by impingement thereon, selected portions of material 86 disposed over surface 100 to at least a partially consolidated (e.g., semisolid) state. The use of mirror 94 lengthens the path of the laser beam, effectively doubling same, and provides a more vertical beam 98 than would be possible if the laser 92 itself were mounted directly above platform surface 100, thus enhancing resolution.

A17

Please replace the first full paragraph on page 20 with the following:

If a recoater blade 102 is employed, the process sequence is somewhat different. In this instance, surface 100 of platform 90 is lowered into unconsolidated (e.g., liquid) material 86 below surface level 88 a distance greater than a thickness of a single layer of material 86 to be cured, then raised above surface level 88 until platform 90, a substrate disposed thereon, or a structure being formed on platform 90 or a substrate is precisely one layer's thickness below blade 102. Blade 102 then sweeps horizontally over platform 90 or (to save time) at least over a portion thereof on which one or more objects are to be fabricated to remove excess material 86 and leave a film of precisely the desired thickness. Platform 90 is then lowered so that the surface of the film and surface level 88 are coplanar and the surface of the unconsolidated material 86 is still. Laser 92 is then initiated to scan with laser beam 98 and define the first layer 130. The process is repeated, layer by layer, to define each succeeding layer 130 and simultaneously bond same to the next lower layer 130 until all of the layers of the object or objects to be fabricated are completed. A more detailed discussion of this sequence and apparatus for performing same is disclosed in U.S. Patent 5,174,931, previously incorporated herein by reference.

A18

Please replace the third full paragraph on page 21 with the following:

In practicing the present invention, a commercially available stereolithography apparatus operating generally in the manner as that described above with respect to apparatus 80 of FIG. 17 is preferably employed, but with further additions and modifications as hereinafter described for practicing the method of the present invention. For example and not by way of limitation, the SLA-250/50HR, SLA-5000 and SLA-7000 stereolithography systems, each offered by 3D Systems, Inc. of Valencia, California, are suitable for modification. Photopolymers believed to be suitable for use in practicing the present invention include Cibatool SL 5170 and SL 5210 resins for the SLA-250/50HR system, Cibatool SL 5530 resin for the SLA-5000 and 7000 systems, and Cibatool SL 7510 resin for the SLA-7000 system. All of these photopolymers are available from Ciba Specialty Chemicals Corporation.

A19

Please replace the paragraph bridging pages 21 and 22 with the following:

By way of example and not limitation, the layer thickness of material 86 to be formed, for purposes of the invention, may be on the order of about 0.0001 to 0.0300 inch, with a high degree of uniformity. It should be noted that different material layers may have different heights, so as to form a structure of a precise, intended total height or to provide different material thicknesses for different portions of the structure. The size of the laser beam "spot" impinging on the surface of material 86 to cure same may be on the order of 0.001 inch to 0.008 inch. Resolution is preferably ±0.0003 inch in the X-Y plane (parallel to surface 100) over at least a 0.5 inch × 0.25 inch field from a center point, permitting a high resolution scan effectively across a 1.0 inch × 0.5 inch area. Of course, it is desirable to have substantially this high a resolution across the entirety of surface 100 of platform 90 to be scanned by laser beam 98, such area being termed the "field of exposure", such area being substantially coextensive with the vision field of a machine vision system employed in the apparatus of the invention as explained in more detail below. The longer and more effectively vertical the path of laser beam 96/98, the greater the achievable resolution.

A20

Please replace the paragraph bridging pages 22 and 23 with the following:

Referring again to FIG. 17, it should be noted that apparatus 80 useful in the method of the present invention includes a camera 140 which is in communication with computer 82 and preferably located, as shown, in close proximity to mirror 94 or another optics and scan controller located above surface 100 of support platform 90. Camera 140 may be any one of a number of commercially available cameras, such as capacitive-coupled discharge (CCD) cameras available from a number of vendors. Suitable circuitry as required for adapting the output of camera 140 for use by computer 82 may be incorporated in a board 142 installed in computer 82, which is programmed as known in the art to respond to images generated by camera 140 and processed by board 142. Camera 140 and board 142 may together comprise a so-called "machine vision system" and, specifically, a "pattern recognition system" (PRS), operation of which will be described briefly below for a better understanding of the present invention. Alternatively, a self-contained machine vision system available from a commercial vendor of

A21

A21 cont'd

such equipment may be employed. For example, and without limitation, such systems are available from Cognex Corporation of Natick, Massachusetts. For example, the apparatus of the Cognex BGA Inspection Package™ or the SMD Placement Guidance Package™ may be adapted to the present invention, although it is believed that the MVS-8000™ product family and the Checkpoint® product line, the latter employed in combination with Cognex PatMax™ software, may be especially suitable for use in the present invention.

Please replace the third full paragraph on page 25 with the following:

A22

Each layer 130 of stabilizer 50 is preferably built by first defining any internal and external object boundaries of that layer 130 with laser beam 98, then hatching solid areas of stabilizer 50 located within the object boundaries with laser beam 98. An internal boundary of a layer 130 may comprise a through-hole, a void, or a recess in stabilizer 50, for example. If a particular layer 130 includes a boundary of a void in the object above or below that layer 130, then laser beam 98 is scanned in a series of closely spaced, parallel vectors so as to develop a continuous surface, or skin, with improved strength and resolution. The time it takes to form each layer 130 depends upon its geometry, the surface tension and viscosity of material 86, and the thickness of the layer.

Please replace the first full paragraph on page 26 with the following:

A23

Alternatively, stabilizers 50 may each be formed as a partially cured outer skin extending above surface 14 of semiconductor device 10 or above surface 24 of test substrate 20 and forming a dam within which unconsolidated material 86 can be contained. This may be particularly useful where the stabilizers 50 protrude a relatively high distance 54 from surface 14, 24. In this instance, support platform 90 may be submerged so that material 86 enters the area within the dam, raised above surface level 88, 88A and 88B (FIG. 18) and then laser beam 98 activated and scanned to at least partially cure material 86 residing within the dam or, alternatively, to merely cure a "skin" comprising the contact surface 52. While material 86 within contact surface 52 will eventually cure due to the cross-linking initiated in contact surface 52, a final cure of the material of the stabilizers 50 may be subsequently accelerated by broad-source

A23 cont'd

UV radiation in a chamber, or by thermal cure in an oven. In this manner, stabilizers 50 of extremely precise dimensions may be formed of material 86 by apparatus 80 in minimal time.

Please replace the second full paragraph on page 26 with the following:

A24

Once stabilizers 50, or at least the outer skins thereof, have been fabricated, platform 90 is elevated above surface level 88 of material 86 and platform 90 is removed from apparatus 80, along with any substrate (e.g., semiconductor device 10, test substrate 20, or wafer 72 (see FIG. 16)) disposed thereon and any stereolithographically fabricated structures, such as stabilizers 50. Excess, unconsolidated material 86 (e.g., uncured liquid) may be manually removed from platform 90, from any substrate disposed on platform 90, and from stabilizers 50. Each semiconductor device 10 or test substrate 20 is removed from platform 90, such as by cutting semiconductor device 10 or test substrate 20 free of base supports 122. Alternatively, base supports 122 may be configured to readily release semiconductor device 10, test substrate 20, wafer 72, or another substrate. As another alternative, a solvent may be employed to release base supports 122 from platform 90. Such release and solvent materials are known in the art. See, for example, U.S. Patent No. 5,447,822 referenced above and previously incorporated herein by reference.

Please replace the second full paragraph on page 27 with the following:

A25

It should be noted that the height, shape, or placement of each stabilizer 50 on each specific semiconductor device 10 or test substrate 20 may vary, again responsive to output of camera 140 or one or more additional cameras 144 or 146, shown in broken lines in FIG. 17, detecting the protrusion of unusually high (or low) conductors which will affect the desired distance 54 that stabilizers 50 will protrude from surface 14. In any case, laser 92 is again activated to at least partially cure material 86 residing on each semiconductor device 10 or test substrate 20 to form the layer or layers of each stabilizer 50.